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ABSTRACT

This report discusses the potential for computers and other educational technologies to aid in school restructuring in New York State. Issues involved in such a restructuring are examined and include: (1) the need for a common effort in creating a state program; (2) current practices and current realities in the classroom; (3) current uses of such technologies as microcomputers, video, and multimedia instruction; (4) access to computers and computer information; and (5) current use of computer assisted instructional software for problem solving, manipulation of data, and cooperative learning. The provisions of the Long Range Plan for Technology in Elementary and Secondary Education in New York State are briefly reviewed with emphasis on the provision of daily access to instructional technology innovations for students, training for teachers in technology applications, and a greater role for businesses to play in helping school restructuring. (This plan was adopted by the New York State Board of Regents in June 1990.) The report concludes by citing New York State's leadership in the use of technology; a 6-year joint study being conducted with the Education Department to test new approaches using comprehensive technology systems donated by IBM; the donation by IBM of a major computer laboratory for training teachers in each of 12 postsecondary institutions; and the implementation of computer links between and among the state, school districts, and individual educators through a system called Technology Network Ties (TNT). It is noted that nothing in this report is to be construed as an attempt to aid or hinder the passage of any federal or New York State legislation. (DB)

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Technology In New York's Classrooms

One Key To Improving Educational Outcomes

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The Public Policy Institute of New York State, Inc.

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March 1991

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Executive Summary

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1. Overview

Computers and other advanced technology offer a tremendous potential for restructuring the educational process — and improving its results. But even in New York State, which is a national leader in these areas, the full potential has not begun to be tapped. **Page 1**

2. The reality today

Despite the potential offered by today's technology, most classrooms are organized around "chalk and talk" — and are based on technology that dates to frontier days. **Page 5**

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Technology which is readily available today can make a dramatic difference in the educational process. And on the horizon is even more advanced technology that will help students explore and learn more independently. **Page 13**

4. A plan for the future

New York State is off to a good start in planning for a high-technology future in the schools. The state has a technology master plan; a state-run infrastructure for technology ties among the schools; and major help from the private sector. **Page 18**

5. Moving ahead

Advanced technology could become much more common in schools, with the investment of a relatively modest portion of school budgets. Business can help start the process. **Page 22**

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Section 1

Overview

Old challenges; new methods

Like his father — and his grandfather — before him, the 15-year-old boy is supposed to be studying Tennyson's poem, *Ulysses*. But just looking at the words, frankly, doesn't turn him on as much as his English teacher might like:

> *"It little profits that an idle king,*
> *By this still hearth, among these barren crags,*
> *Matched with an aged wife, I mete and dole*
> *Unequal laws unto a savage race*
> *That hoard, and sleep, and feed, and know not me."*

What does this stuff mean, anyway? No doubt his teacher could tell him — if she had the time. But with five classes averaging 28 kids each, the teacher is hard-pressed to help every one with individual explanations of the material.

But suppose the boy had access to an interactive multimedia system, built around a small computer, which would allow him to explore this poem and its context on his own.

Suppose the poem was displayed, not on paper, but on a computer screen, surrounded by little boxes that mark pathways to more knowledge about the story of Ulysses, about poetry, about ancient times, about heroes.

Suppose the boy could use a "mouse" on the computer to click on one of his screen's boxes, the one marked "INTERPRET." Suppose the computer screen then displayed the faces of, say, six different actors who could read the poem out loud to him — and another click promptly brought up a video of the actor of his choice, reading those dramatic words with professional skill.

Suppose that got the boy interested in knowing more, and he clicked on another little box marked "CONTEXT." Instantly, up comes a

video illustrating the story of Ulysses, the pirate king, the adventurer, who returns after 20 years and finds himself unbearably restless.

But what is that word, "mete," anyway? Suppose the boy could click on the word, click a box marked "DEFINE," and get his answer right away.

Suppose the boy could click on a box marked "EXPLORE," and then one marked "STYLES." Now there's a short video describing different forms of poetry, from ancient Japanese literature to modern rap music.

Suppose the boy could click on "heroic hearts," then on the "EXPLORE" box again, and bring up a video recounting the role of heroic figures in cultures around the world. Suppose that was followed by a dramatic reading of the whole poem.

Suppose the reading was voiced over a video showing modern-day events and heroes, climaxing with the famous scene of a lone man facing down a tank in Tienanmen Square, as the voice concludes:

"To strive, to seek, to find, and not to yield."

Suppose that now the poem has a lot more meaning to the boy.

This isn't 'suppose'

Impossibly futuristic as it might seem, this scenario isn't a "suppose" at all. The technology already exists — and could probably be produced at a surprisingly low unit cost, if installed in schools on a massive basis.

The *Ulysses* lesson also exists; it was developed for IBM Corporation, which has stunned audiences around the nation with this dramatic demonstration of the potential which technology brings to the classroom.

James E. Dezell, Jr., the general manager of IBM Educational Systems, says the demonstration proves that advanced technology is the answer to some key questions: "How do we motivate high-tech kids in a low-tech classroom? Can we make education more exciting than MTV?"[1]

And the same technology which makes a literature lesson come alive can be, if anything, even more powerful when applied to math, the physical and life sciences, history, and more.

[1] *"Restructuring Education Through Technology,"* keynote address at IBM Schools Executive Conference, Feb. 2, 1990, Palm Springs, Calif.

Stunning as the *potential* is, however, the current *reality* is something else again. For the most part we are still using 19th Century technology to educate the work force of the 21st Century.

Experts in technology and organization say that the nation's school system lags far behind private business, and behind other sectors of government, in adopting the new technology needed to improve quality and productivity.

New York State has done more than many other states in planning for the use of technology in the schools. But even in New York — home of the nation's healthiest school budgets, and home to some of the world's leading high-technology companies — the schools suffer marked shortages of even the most inexpensive technology, such as VCRs. Statewide, New York has only about one video playback device for every seven teachers, and only about one computer in the schools for every 17 students[2]; the ratios are far worse in many poorer districts. Even where they are present, there are indications that video and computers are underutilized, underpowered and imperfectly integrated into the learning process.

Beyond the instructional role of technology, the enormous potential of computers for helping teachers with their endless paperwork, and for improving the administration and accountability of the educational system, is also largely untapped.

Needed: a common effort

If the full potential of technology for the schools is to be realized in New York, the state needs a cooperative effort by the public and private sectors to ensure that the appropriate technology is developed, is provided to the schools, and is fully utilized.

Some solid steps have been taken in that direction.

The Board of Regents, the governing body for education in the state, has adopted a comprehensive statewide plan for technology in education, laying out a framework for "the pervasive integration of appropriate technology within all levels of our educational system." Technology, and the school restructuring it can facilitate, are integral to the "New Compact for Learning," a comprehensive reform plan designed by Education Commissioner Thomas Sobol. The state Education Department has created a statewide computer network, called Technology Network Ties, which helps educators exchange advice, manage financial and student information, and access instructional software.

Governor Cuomo has announced an experimental program, funded and implemented by IBM, to install a model computer network in

[2] State Education Department, *"Long-Range Plan for Technology in Elementary and Secondary Education in New York State,"* June 1990, p. 10.

each of 13 elementary schools. The system includes special teacher presentation systems, multiple IBM computers in every classroom, and links to the statewide educational network and to teacher's colleges.

Apple Computer, Inc. has donated additional computers and software to bring five schools around the state up to what it considers the state of the art, and Data General Corporation has announced computer demonstration projects in two secondary schools.

The state has provided hardware and software aid to local school districts totalling some $100 million since 1984, and the districts have at least matched that amount of spending. In fact, proprietary estimates are that total spending on technology of all kinds by elementary and secondary schools in New York State now totals in excess of $200 million a year.

But estimates for implementing a comprehensive program of installing basic computers in all classrooms in the state run as high as $3 billion — and perhaps much more to install interactive, multimedia technology like that used in the *Ulysses* demonstration.

Nor is money the only issue.

The organization of the educational process needs to be changed to take advantage of the potential of the new technology.

Teachers need training to help them make the most of existing and emerging technologies.

And both the classroom, and the school administration process, need to be changed in order to garner some of the productivity improvements which technology offers. The schools will not be able to afford all the technology they need unless they — like private business and like other sectors of government — find ways to ensure that *spending* money on technology *saves* money in other areas.

All these problems are complex, but none of them are unsolvable. And the solutions must be found. Our educational performance is now being surpassed by one competing nation after another. Our nation's continued prosperity depends upon closing that gap, and technology is one way to do it.

Section 2

The reality today

Chalk and talk

If the telephone system had changed as slowly as the school system has, you'd still have to turn the crank and tell an operator the phone number you want, before you could make a call. From the days of the one-room schoolhouse, the core technology of the classroom has stayed pretty much the same: chalk, a blackboard, paper, pencils, and books.

Much of what we take as a "given" about how the educational process should be organized is, in fact, largely a product of the technology which was available when the current prototype was devised.

Pupils work mostly with paper and pencil and books because those were the technologies available in frontier days. A single teacher interacts with a fairly large group of pupils because, after all, even a group of, say, 10 would be too much to give individual attention to; yet a class shouldn't be much larger than, say, 35, because more than that many will have a hard time seeing the blackboard.

The class size requires that teachers spend a disproportionate share of their time lecturing, and that students spend a large proportion of their time in synch with their fellows rather than working at their own pace. Classes are organized by age level and by subject matter to make the best use of this lecture approach. And so on.

An outdated model

Over the past century, this "chalk and talk" model has worked remarkably well in mass-producing students prepared for an industrial economy. In fact, the school system was and is a bit like an old-fashioned factory — with an emphasis on following instructions, discipline, and routine tasks.

The American educational process, in other words, roughly matched the structure and needs of the industrial system for which students were being prepared.

This is no longer the case, however. The illiterate Third World is rapidly turning into the educated Third World. Workers with the basic skills needed for mass-production jobs are now available all over the world, at wage rates far below what is needed to maintain what we consider an American standard of living.

If Americans are to compete in this new global economy, and earn wages commensurate with the high (and steadily improving) standard of living which we have come to expect, we must be able to handle jobs which require much higher "value added" skills.

These skills include a lot of different things: the ability to process information symbolically, to read complicated manuals and diagrams, to interact personally with customers, to master very high degrees of specialization, and more. Wide-ranging though the differences in these new, higher-order skills may be, they have one common thread: they require that workers be able to work and learn and plan and react *independently*, rather than by rote.

Yet independent working and learning is the very thing that our current classroom model of education, with one teacher dealing with 25 or more students at a time, has the most difficulty producing.

Society can't afford the money which would be required to deal with this problem by drastically increasing the teacher-to-student ratio, to one-to-three or so. The only alternative, therefore, is to use technology to help teachers maximize the help and supervision which can be given to the independent work and learning of their students.

Video: the first sign of change

The first widespread change in the technology used in the classroom — and still the most common, in terms of hours of contact with students — was the adoption of ever-improving forms of video technology. First filmstrips, then motion pictures, then broadcast educational television, and now video cassette recorders, have allowed teachers to access a wealth of new material.

According to the latest available figures, public schools in New York own more than 38,000 television receivers and 27,400 video playback devices. But that's only about one VCR for every seven classroom teachers. Even with sharing and swapping, only about one classroom teacher in every three reports having used television for instruction at all.[1]

A basic video playback setup — with a large-screen television and a VCR — is on a per-pupil basis the most inexpensive "advanced"

[1] Peter F. Stoll, "The Expansion of Technology in New York State's Schools," *Journal of the New York State School Boards Association*, August 1990, p. 10. Also, State Education Department, "Long-Range Plan for Technology in Elementary and Secondary Education in New York State," June 1990, p. 10.

technology available for the classroom. Yet all by itself it can provide access to a wealth of new material.

If a picture is worth a thousand words, then video can illustrate situations and concepts which are much harder to grasp from reading or listening. Video offers teachers a chance to bring into the classroom specialized lessons they would not have had time to prepare themselves. Video can provide learning experiences which may go beyond the expertise of the individual teacher -- say, science lessons on topics in which an elementary school teacher may not specialize. There are, in fact, some 15,000 hours of classroom programming available on video for schools in New York State. And video picks up on the method by which most of today's kids are getting most of their information: by the time of high-school graduation, a typical student of today will have watched 20,000 hours of television, compared to only 12,500 hours in the classroom.[2]

Given the cost-benefit ratio, ensuring that video playback technology is available in every classroom would be a reasonable first goal for any technology program in New York schools — and it is, indeed, a key objective of the Regents' long-range technology plan.

But powerful as it is, simple video playback technology is only an extension of the conventional classroom model, with the students sitting quietly, watching and listening to a presentation. It has the advantage of being able to illustrate things that the teacher can't, but the limitation of not being able to stop and answer student questions.

Why computers

This core need for interaction — for a learning process that can deal with students individually — is something only teachers, or computer technology, can meet.

The potential of computers is so obvious, in fact, that for almost 30 years, it has inspired a kind of guerrilla campaign by a growing number of visionary teachers and principals in the field. Long before anybody began to make "comprehensive plans" for the use of computer technology, these grass-roots educators were sneaking computers into the educational process.

The first use: drill

These pioneers, or "gurus" as they sometimes call themselves, quickly discovered that even simple computers with inexpensive, sometimes home-grown software were pretty good at drilling students on things like math facts.

Students could get instant feedback on right and wrong answers. The computer could quickly adjust the difficulty and pace of the drill to

[2] Bruce A. Taylor, "An Agent for Education Change," *Human Capital*, April 1990, p. 25.

the abilities of the individual student, and could keep score. Commercial software soon emerged that added a video game-like interface to much of the drill — such as the famous *Math Blaster* series.

And educators quickly discovered that these techniques could yield special benefits to students who were having difficulty in their classwork. An early experiment at an inner-city elementary school in Chicago got these reports from teachers:

> *"What I really like about it is that they have 30 minutes of individual attention, whether it's the teacher or the machine. Children in a community like this don't always get that individual attention."*
>
> *"I have kids who don't come to school in the morning, but they'll come in the afternoon because they don't want to miss the computer. The kids love it. And you don't have any behavior problems, because they are really interested in what they are doing."*[3]

At that school and at many others, however, computers have not really not been integrated into the classroom; they are an adjunct, sometimes a distraction. Often the computers are put in a special lab, where a whole class will go at once to drill on them. Students who especially need the drill may not get any more time on it than their fellows do; on the other hand, students who need more drill may be sent out of the classroom to get it — in which case they may miss classroom instruction.

This situation led one reformer to worry: "Pencils never would have become useful educational tools, if students had been permitted to use them only in 'pencil labs'."[4]

Computers teaching about computers

From the first, there has also been an attempt to use computers to teach students, especially in the upper grades, about the workplace use of computers — the so-called "computer science" courses.

The idea seemed logical enough, given the increasing pervasiveness of computers in the working world, and given projections that programmers and other computer professionals will be in chronically short supply unless the schools start training more of them.

The only danger is if this limited use of computers convinces some school systems that they have "gone computer" as much as they need to. And there were some early indications that was happening. The National Assessment of Educational Progress reported that a 1985-86

[3] Harry Donahov, "A School Where Computers Make a Difference," *Principal*, January 1986, p. 25.

[4] Kay Gore, "If You Meet the Computer Guru on the Road, Kill Him (or Her)," *Computers in the Schools*, Vol. 6, #3/4, 1989, p. 18.

survey found that computers in schools were being used almost exclusively to teach *about* computers, rather than being used in other subject areas.[5]

The next step: courseware

Only in the last few years, and so far only in a relatively limited number of programs implemented in only a relatively small number of schools, have computers begun to be integrated into regular classroom work on regular academic subjects.

One particularly spectacular example of this approach, which is known in the trade as "courseware," is IBM's "Writing to Read" program. It represents a whole new curriculum, in effect, for kindergarten and first-grade pupils learning to read and write — one in which the regular use of computers is integral to the curriculum from Day One.

This program is now used in hundreds of schools around the country; it is being implemented throughout the *entire* state of Mississippi, with the help of private philanthropy. It has produced millions of graduates and has shown dramatic improvements in early writing and reading ability. But as all "courseware" must eventually do, it requires that computers be available to every student every day — an investment most school districts have not been able, or willing, to make.

Similar work has been done in other areas. IBM is now testing a follow-up "Writing to Write" program, and a set of second-grade math lesson plans, in which the use of computers is a constant. There is extensive courseware available in the sciences, enabling students to simulate the results of experiments in, say, chemistry, much more rapidly and flexibly than they can do in the lab. There are even programs which let students experiment with volcanic eruptions, radioactive materials, and explosives — all without blowing up the school![6]

Yet the widespread, effective use of these kinds of programs requires that computer technology be much more pervasive in the schools than it is today — and that the schools reorganize the way they work, to take advantage of them.

"After more than two decades of research, the task of successfully integrating computer technology into regular instruction still appears daunting," *Science* magazine reports. "Teachers still have little

[5] Michael E. Martinez and Nancy A. Mead, *"Computer Competence: The First National Assessment,"* Educational Testing Service, April 1988.

[6] Office of Technology Assessment, "Power On!: New Tools for Teaching and Learning," September 1988, p. 3.

training in computer use, much less how to choose and employ software productively.... There is a big gap between the theorists, and those on the front lines in the classroom."[7]

One of those "theorists" confesses, "As gurus, we seem blind to how little time most teachers actually have to spend on preparation for the implementation of computers.... Rare is the school or district which has administrators sit down with teachers, analyze what problems teachers have, and explore how computers may address some of the problems."[8]

And those are just the limitations of implementing relatively simple courseware. For computers to be useful as full-scale knowledge explorers for students — as in the case of the *Ulysses* demonstration — requires that they be not only more pervasive, but also much more advanced technologically.

And, oh yes, paperwork

Even as computers are gradually become more important in instruction, they are also playing an ever larger role in dealing with that other main product of the school system — paperwork. A small but growing minority of teachers and administrators, like office workers in other sectors before them, are finding that computers give them a chance of getting on top of the ever-growing demands for reports and plans and so on.

Wrote one teacher, Richard Adams, "There comes a point in the computer-in-the-schools movement when all self-respecting teachers should say to themselves, 'Forget about the kids, what can the computer do for *me*?'"

He discovered, as have thousands of other teachers, that computers can help with lesson planning, test preparation, scoring, grading, reporting, budgeting and everything else. Well, *almost* everything. "No one has designed a computer that can take over bathroom patrol or carry on proper faculty room gossip," Adams noted.[9]

Yet the widespread lack of equipment, training and organization has meant that many of the minority of teachers who use computers for their "office" work have had to do so on their own time, often on a self-taught basis, often on equipment they bought with their own money. Much of the software, spreadsheet templates and other material keyed to teachers' needs was developed by individual

[7] Constance Holden, "Computers Make Slow Progress in Class." *Science*, May 26, 1989, pp. 906-907.

[8] Kay Gore, op. cit. pp. 16-19.

[9] Richard C. Adams, "Why I Moved My Micro to the Teacher's Desk," *Instructor*, Jan. 1985, pp. 56-57.

teachers on their own time, and made available to colleagues for free, via electronic bulletin boards, through disk swaps, and so on.[10]

Numbers growing; needs still high

Despite the financial and procedural obstacles, the acquisition of computers by school systems nationwide has been growing steadily. In 1981, only about 10 percent of U.S. elementary schools, and 40 percent of high schools, had even a single computer on the premises; by 1987, that count had soared to 95 percent of elementary schools, and 99 percent of high schools.[11] Nationwide, today there is about one computer for every 30 students in elementary and secondary school.

Thanks to generous school budgets, state assistance, and technology awareness, New York State's ratio is almost twice as good as the nation's — about one for every 17 students, as noted above.

The state Education Department reports that a 1989 survey found that 1.9 million of the state's 3.1 million students, and 84,000 of the 183,000 classroom teachers, make what it called "regular use" of computers for instruction.

But there may be less than meets the eye, in these upbeat survey numbers (which appear to have been generated in part to convince a reluctant educational establishment to get on the computer bandwagon).

Even the one-computer-to-17-pupils ratio which New York enjoys, for example, is a far cry from the one-to-four ratio or so that is needed to make the best use of courseware like "Writing to Read." A large number of inner-city and rural schools in New York have few, if any, computers.

And of the 163,000 or so computers owned by New York public schools in 1989 (the most recent year for which statistics are available) more than three-quarters were older models; fewer than 30,000 were IBM PS/2's, Apple Macintoshes and other current models required to run today's leading-edge courseware.[12]

As to the 1.9 million students said to be making "regular use" of computers in New York schools, the actual survey defined "regular use" simply as any "direct interaction with a computer or computer terminal, as a part of a planned sequence of instructional activities."

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[10] The computer and professional forums on the national information service called CompuServe, for example, are full of messages and files posted by computer-savvy teachers to help each other. Similar interchange occurs on New York State's TNT network.

[11] "Power On," p. 7.

[12] State Education Department, Office of Planning, Testing and Technological Services. The schools are buying as many as 50,000 new computers a year, however, and marketplace data indicate that most of these are more advanced models.

A real-world example

There is no comprehensive survey indicating exactly what that "regular use" means in quantifiable terms — how many hours a week, for example, of drill, or courseware, or computer science, or whatever. Anecdotal evidence, however, indicates that "regular" can mean pretty irregular — and, indeed, that the current computer resources of schools make that inevitable.

Take, for example, the experience of Mary Fiess, a mother who serves as a volunteer for computer instruction at an elementary school in a prosperous suburb of Albany. She was selected because she uses a computer at her part-time job, which qualified her as an "expert."

The elementary school in question has been able to acquire one computer for each classroom, plus a good selection of software. But that isn't enough to integrate the computers into the regular curriculum, so they can be used only when most of the students in a class are involved in some other kind of independent desk work. The teachers in the school are interested in and open to computers; unfortunately, they don't appear to have received much training. A good number of parental volunteers is available, but they haven't had any training, either.

In the first-grade class for which Fiess volunteers, one hour is set aside on each of three days of each week for students to work with volunteers on computer drill programs and on Logo, a programming language which helps teach problem-solving skills. They work with each pupil in a 15-minute session, while the rest of the class does its deskwork. Thus, this particular example of "regular" use adds up to about a half-hour of computer use each month, for each of the 21 kids in the class.

Still, it's hard to keep a good kid down. Fiess was having trouble one day showing another volunteer what to do. So the other volunteer's seven-year-old son sat down in his lap and showed his dad how to make the computer go.

Section 3

The potential

Useful now; even better things to come

Frustrating as the current status of technology in the schools may be, the immediate and future gains to be realized from its proper employment are undeniable. And as most parents and teachers alike can tell you, the kids are more than ready. The point was made by one of those "Pepper ... and Salt" cartoons in the *Wall Street Journal*.[1] A little girl stands in front of her teacher's desk and says, "I'm tired of dusting the erasers, Mrs. Feeney. Can I debug the educational software instead?"

We know also that just as the kids are ready, so, too, is the technology. There is enough tested, well-developed courseware already available, using conventionally available and relatively inexpensive computer and video playback technology, to make dramatically more productive use of the time of pupils and teachers alike — and to help improve results for everybody from beginning readers to advanced calculus students.

Even more impressive is the future potential of technology, particularly interactive, multimedia approaches that can let teachers design compelling lessons, and can give students an almost addictive tool for exploration on their own.

At a time when Americans are increasingly aware of the need for a sweeping renewal of our educational system, technology is ready to facilitate the change to a new, more productive, more challenging style of learning.

The real questions are: Are the *schools* ready? And how do we help them make the change?

[1] May 14, 1990.

What's here now?

Advocates of technology in the schools are sometimes so caught up in the potential of the emerging new technologies, such as those demonstrated in the *Ulysses* project, that they may overlook the very considerable potential of technologies and programs which are already widely available. Those existing resources are impressive enough in their own right, however.

The U.S. Office of Technology Assessment, in a 1988 report entitled *Power On!: New Tools for Teaching and Learning*, catalogued 12 basic educational uses of technology which it said had already proven valuable. It addition to the drill, computer skills and administrative uses mentioned above, the report cited:

- **Writing skills.** Even the use of basic word processing programs — not to mention whole new curricula like the IBM "Writing to Read" program — has been shown to improve student writing skills, simply by easing the physical burden of writing and revising.

- **Problem solving.** This kind of skill — a crucial, higher-order thinking skill needed by high-value-added workers of the future — has long proven difficult to teach by conventional means. Computer simulations and games have been effective, as have computer programming lessons, which require breaking problems down into discrete entities.

- **Understanding abstract mathematics and science concepts.** Studies indicate that when students use software which lets them experiment with and visually graph abstract concepts, they develop a deeper understanding of these concepts, and do so more quickly, than peers who have not had these advantages.

- **Simulation in science, mathematics and social studies.** Computer programs can, for example, allow students to run through (and see the results of) a whole series of math or science experiments in less time than it would take to do a single one in the laboratory. Or they can allow students to "role play" historical or political figures, to gain insights in the social sciences.

- **Manipulation of data.** The use of computer database management systems has helped teach students to break information into its components, understand the relevant parts, and sort and select information intelligently.

- **Access for the handicapped.** Computers can dramatically expand the communications and learning access of handicapped pupils.

- **Access in remote locations.** Both video technology, and computer networks, are helping teachers and students communicate with peers in other towns, states and even countries — and are

delivering specialized learning that would otherwise be unavailable in rural areas.

- **Individualized learning.** Computer programs can adapt to each individual student's prior knowledge and rate of learning.

- **Cooperative learning.** Telecommunications makes it easier for students to share information with others; a state program provides properly equipped New York schools, for example, with connections to students in Moscow.

Finally, there is evidence that in certain circumstances, computers seem to do a better job than conventional educational methods. "Computer technology seems to enhance motivation for learning," writes Shirley M. Malcom of the American Association for the Advancement of Science. "Many researchers and practitioners suggest that this is related to the computer's ability to be non-judgmental, to provide immediate feedback, to allow self-pacing, and to help raise students' 'status' in their schools."[2]

The plain fact that computers can make learning seem more *fun* to the Nintendo generation has lately caught the imagination of people and organizations in many different sectors. Not the least of them is Nintendo itself, which has created a $3 million fund to help M.I.T. professor Seymour Papert, a seminal thinker in learning technologies, develop ways to integrate learning and play.

How well does it work?

Although there is a widespread conviction that computers can help improve learning, their very scarcity in the schools has impeded the development of any massive, empirical database proving once and for all just what they can, and cannot, do. Even where school systems are using computers off and on, almost none have engaged in the wholesale restructuring which will test their full potential.

What evidence can be gathered, however, is clearly positive.

A survey conducted by the Bank Street College of Education, for example, sought out classroom computer "gurus" nationwide — deliberately choosing to study the results achieved only by those teachers who have used computers most extensively. The survey, covering 608 teachers at 576 schools in 50 states, found that with computers, students can take on more ambitious projects; learn to approach those projects in ways that are both more adventurous and more analytical; better understand hard-to-grasp or abstract concepts; and take the initiative in designing and pursuing their own projects.[3]

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[2] Malcom, "Technology in 2020: Educating a Diverse Population," in Raymond S. Nickerson and Philip P. Zodhiates, eds., *Technology in Education: Looking Toward 2020*, Lawrence Erlbaum Associates, Hillsdale, N.J., 1988.

[3] Susan Chira, "Making Computers Better Teachers," *The New York Times*, Sept. 5, 1990, p. B7.

The public school system in Orangeburg, S.C., with a student base that is 80 percent minority and 70 percent poor, has heavily restructured over the last six years to emphasize the use of computers, especially in remedial efforts. The number of children achieving national "norms" at the various grade levels has increased from 14 percent to 59 percent.[4]

The school district in Merton, Wis., a rural/suburban district that is predominantly middle and upper-middle class, began heavy use of computers after adopting a long-range plan in 1984 which promised that "each student has a right to an education which is personalized." It reports that computers have helped it deliver on that promise while improving efficiency; the district has one of the lowest total per-pupil costs in the Milwaukee area.[5]

Nothing on that kind of district-wide scale has yet been implemented anywhere in New York State.

Beyond courseware

These and other success stories have been based in part on moving from the computer-"lab," drill-oriented, haphazard use of computers, to fuller integration of computer courseware into the daily learning activities of the classroom.

But on the horizon is another step, beyond courseware, involving the use of computers to help teachers provide customized, dramatic lesson plans, and to help them give students a greater opportunity to explore, work and learn on their own. This next step involves the use of what the trade calls "interactive multi-media," both for teacher presentations and for student exploration of the type dramatized in the *Ulysses* example.

The multi-media approach would be built around new technology enabling a computer to control various other devices, including, say, large-screen television displays, VCRs, laser video disks, CD-ROMs, audio equipment, laboratory equipment, and so on.

Teachers could use such a system to prepare lessons which would integrate bits and pieces of various video tapes, historical texts and other items into a presentation on, say, the Emancipation Proclamation — or which would allow rapid exploration of differing approaches to a mathematical or scientific problem. Individual students could use such a system to look up and explore information from a wide variety of sources, much as if they had a whole library on their desk — only one with video and sound as well as text.

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[4] Taylor, "An Agent for Education Change," *Human Capital*, April 1990, p. 26.

[5] Dr. Robert Gilpatrick, district superintendent, *"An Educator's Rationale for Using Teaching and Learning with Computers,"* monograph privately circulated.

Although the integration of this technology into education is still in the earliest stages of development, it is real and workable (though expensive) now, and it is already getting a surprising amount of use. The New York State School Boards Association, for example, has formed a new Department of Technology Services to promote this kind of approach, and is already distributing a video-disk based package for learning the physical sciences.

The need to restructure

However promising the technology, however, it will not reach its full potential until and unless the school system collectively, and education professionals individually, revise the educational process to move beyond the "chalk and talk" structure.

Robert K. Branson, a specialist in educational process, writes that advanced technology is the ideal tool for implementing a new approach to learning which "optimizes student time-on-task ... increases the quality and quantity of feedback ... and paces instruction to students' capabilities." But he says that for such an approach to work, the school system must first make the drastic switch from "teacher-centered, classroom-controlled instruction" to "learner-centered, performance-paced instruction."[6]

The truth is that despite all the "master plans" done at various levels, most of the successes so far in advancing the use of technology in education have been the result of stubborn individualism, and/or blind luck.

The Bank Street study, for example, reported that most of the teachers who made heavy and productive use of computers had done so mostly at their own initiative, were mostly self-taught, and had taken an average of at least five years to scope out ways of making the most of the technology.

If progress in this area is left to depend upon every individual teacher having the freedom, getting the time and taking the initiative to figure out how to use technology on his or her own — well, the job will never get done.

[6] Branson, "Issues in the Design of Schooling: Changing the Paradigm," *Educational Technology*, April 1990, p. 8.

Section 4

A plan for the future

The Catch-22s

Compelling though the arguments for it may seem, as a practical matter getting advanced technology into the classroom has been anything but easy. Unplanned, uncoordinated efforts in that direction confront a veritable sea of Catch-22s.

The computers and video equipment which schools already have, for example, are underutilized, because there aren't enough of them in most schools to allow them to be fully integrated into classroom work. The optimum technology for learning will always cost too much — unless schools buy a lot of it, and pull the unit cost down. But schools can't buy more as quickly as they might like, because of budget constraints. But everybody knows that in other sectors, buying technology has saved money — not increased expenses. But the schools can't realize any savings until teachers have been retrained in, and have fully tested out, the new approaches. But with every minute of the school day already accounted for by various state and other curriculum requirements, when can that training and testing take place? And so on.

The situation cries out for a rational planning approach, in which a vision of a new educational process can be drafted, tested, and modeled for adoption by individual schools.

Fortunately, in New York State that kind of rational planning process is off to a good start — highlighted by a new master plan adopted by the Board of Regents, by the creation of a state-run infrastructure for technology ties among the schools, and by major contributions from the private sector.

The long-range plan

In June of 1990, the Board of Regents, governing body for education in the state, adopted a *Long-Range Plan for Technology in Elementary and Secondary Education in New York State*, outlining ways to ensure that the potential of technology is fully used in both the instructional and administrative functions of the schools in New York State.

The Regents' plan lays out a "vision of the future," with guideposts of the general ways in which the state hopes to see technology employed in the educational process by, say, 1995. This "vision" would provide, among other things, that:

- Students would have "daily access" to "technology-rich learning environments," within the classroom, in library media centers, and/or from home as needed.
- This "daily access" would include the integration of the computer "into the entire instructional program," and the use of multi-media learning environments.
- Students and teachers alike would have access to portable computers for use at the desk and/or at home.
- Teachers would get "comprehensive training" in technology applications, and would participate directly in the technology planning process for every district.
- Teachers would have a workstation for their use in every classroom, for their paperwork needs and for electronic links to colleagues and information sources across the state.
- Administrators would use computers for fiscal and student information systems, for reporting information to the state, and to communicate with colleagues in their district and elsewhere.

Learning by example

The long-range plan says that "the Regents support the complete integration of technology into the teaching/learning environment." But it doesn't say exactly how that future teaching and learning environment should look or how it should be structured. And for a good reason: no one knows, yet.

To find out, the state is now embarked on some studies to implement a leading-edge approach to technology in a number of schools, and see how it works.

The most comprehensive of these programs is sponsored by IBM Corp., in a six-year "joint study" with the Education Department to test out new approaches. IBM is donating comprehensive technology systems — including hardware, software and training — to 13 elementary schools around New York State; IBM is also donating to

each of 12 post-secondary institutions a major computer laboratory for training teachers.

The study project in the 13 elementary schools is the most in-depth effort of its kind yet undertaken anywhere in the nation. For those schools, IBM is providing:

- Four student workstations for each classroom.
- A workstation for each teacher and each principal.
- Networking hardware which links the classrooms and the principal in each building with each other, and with the statewide educational network.
- A central file server laser printer for each building.
- A multi-media presentation system for teacher use in each building.
- A variety of instructional and management software.
- And technical support and training for all participating staff.

The participating schools, IBM and the state Education Department will jointly study the effects of the technology on school operations and on student achievement. As Governor Cuomo said when he announced the program, "this exciting new partnership between business and education will provide our students with access to the cutting edge of educational technology."

Technology Network Ties

New York State is also a national leader in one other key area of technology in the schools: the implementation of computer links between and among the state, school districts and individual educators.

Since 1984, the state Education Department has been developing a system called Technology Network Ties, or TNT. Individual schools are linked to each other through computer connection to a Regional Information Center operated by BOCES (Board of Cooperative Educational Services) or by a metropolitan school district; those regional centers are then linked with each other and with the state Education Department in Albany.

Perhaps the most heavily used aspect of TNT today is its communication function; it allows educators to exchange electronic messages with each other and to engage in on-line conferences on timely subjects.

TNT also provides, however:

- Access to information databases operated by the state, including the on-line distribution of updated regulations and the like.
- "Gateways" to other, national and international networks, with a huge range of information sources and communications capabilities.
- The use of computer-based management and instructional services. Applications under development include a comprehensive school financial management package, with automatic filing of reports required by the state, and a student information database, tracking students' instructional progress as they move through and around the system.
- Electronic distribution of state tests and answer keys.
- The electronic distribution of instructional software for classroom use, at costs much lower than school districts must pay if they purchase software directly in low volumes.

In other sectors of government and in private business, employees have typically started out using computers to enhance their own individual work — and then have later migrated into using them more and more to share information and carry out joint projects with other workers. The TNT system gives the education system in New York a smooth path by which to develop that kind of interchange, as the use of technology in the schools steadily expands.

Section 5

Moving ahead

Obstacles and pathways

The schools sometimes are criticized for moving so slowly in adopting new technology. Business executives can see at a glance, for example, that the average school is doing much less to modernize than is the average successful business.

But from a historical perspective, it could be argued that the schools have made impressive progress in embracing new technologies — when you consider the conservative nature of the school system, the intense politicization of every proposal for changing it, the regulatory and financial constraints under which the schools operate, and the fears which teachers express that this will be one more change foisted upon them without training and without consultation.

Viewed in the context of those problems, the system can be said to have come a long way.

The important issue, however, is not what has held the schools back. The important issue is how to move them forward faster. And it is clear that there are pathways to success, open and ready to be traveled.

Of course, much more has yet to be learned about exactly how to make the best use of technology in the schools. But enough is known already to make a compelling case for a major expansion in that use of technology.

Schools can move ahead, and business can help.

A needed investment

The largest single obstacle to technology in the schools has generally been said to be the simple matter of money. Especially in an era of state aid cutbacks and economic troubles, educators seem predisposed to believe that their budgets are simply too tight to allow significant new spending on computers and other technology.

Yet business has learned to think of new technology not as a cost, but as an investment. Private business, and non-educational sectors of government as well, have found that computers and other technology can serve to ease — rather than exacerbate — problems with budgets.

How can that lesson be applied to the schools?

There are those who argue that technology cannot possibly bring the same kind of savings to the schools, because computers can never replace teachers. And of course, they can't.

But retaining teachers is not the only way that school districts spend money — and, therefore, is not the only place in the school budget to which one can look, when searching for funds to be invested in technology.

In fact, according to the U.S. Department of Education, only about 37 percent of the total spending on elementary and secondary education in New York State every year goes to teacher salaries and benefits. Much of the rest of the money is soaked up in the expenses of administering over 700 local school districts, in regulating at the state level and reporting at the local level, in preparing specialized plans and reports, in paper and face-to-face communications, and so on — all areas of work in which technology could be expected to cut costs.

And there is no reason to believe that computers cannot save any money anywhere in the *instructional* budget. either. On the contrary, there is clear evidence that technology can cut costs, particularly in dealing with students who need special remedial learning outside the scope of regular classroom work.[1] Correctly applied, technology can also improve instructional efficiency, allowing students more "mind on task."

The education system could drastically increase its spending on technology without coming close to what business invests. The average capital investment in equipment and facilities for the U.S. private-sector economy as a whole is about $50,000 per worker; compare that to the $100 to $200 which the typical school district spends each year on materials and tools for each student.[2]

Yet what the school system is already spending on technology could, if modestly increased and tightly focused, provide for state-of-the-art technology in fairly short order.

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[1] Henry M. Levin, "The Economics of Computer-Assisted Instruction," *Peabody Journal of Education*, Volume 64, Number 1, 1989, pp. 52-66.

[2] Lewis J. Perelman, *"Closing Education's Technology Gap,"* the Hudson Institute, Indianapolis, Ind., Nov. 1989, p. 3. This comparison, based on the somewhat sketchy statistics available, is somewhat apples-to-oranges: it contrasts *total* capital investment in business with *annual* spending in the schools. Still, it gives some sense of the size of the gap.

If New York schools currently spend about $200 million a year on technology of one kind or another, that amounts to only about 1 percent of the total school budget.

Suppose the schools merely doubled that percentage — in other words, reallocated a mere 1 percent of the rest of the system's budget to technology. That could equip *every* student with a computer within five years (assuming current trends in school budgets and computer prices continue). Maintaining a 2 percent investment level for five more years could allow extensive investment in more sophisticated, multi-media systems.

What businesses can do

The problem, therefore, isn't that schools absolutely can't afford new technology; it is that, given all the other pressures on them and given the untested nature of educational practice in this area, they are likely to move slowly.

Business, however, might be able to help them move more rapidly. Business can press in general for a restructuring of the schools, including a new focus on technology. And beyond that, one specific, promising new effort is now underway.

To get business involved and to make the best possible use of help available from the private sector, the Board of Regents has prepared a plan for a joint business-school partnership to speed up the installation of technology in the schools.

The plan calls for asking businesses to make donations of equipment and expertise that will help move technology into the classroom.

There is to be particular emphasis on getting technology into poorer schools, which have had the hardest time affording it on their own. The plan also assigns a priority to bolstering the teaching of math and science in the elementary grades — areas in which few elementary school teachers have specialized.

Donations could take the form of relatively inexpensive video playback equipment — a basic technology of which too many schools are woefully short. Schools also need donations of computer equipment (which may include, in some cases, used computer equipment no longer needed by a business — although integrating such equipment into the classroom will take careful planning). The donated computers, new or old, could be used either for direct classroom work — or directly by teachers, to help them with their paperwork and to help them get adjusted to the computer age.

Businesses may also be called upon to donate expertise to help schools and school districts plan for the implementation of technology, and/or to open spots in their computer training programs to teachers and other employees of local school systems.

For its part, the state Education Department has agreed that schools receiving the donations must have plans in place to ensure that the donors face minimal hassles in planning and placing their donations. And legislation will be sought to allow school districts to use these business contributions — as well as, or in addition to, local tax dollars — to qualify for state dollars matching what they have raised locally.

The Business Council of New York State has endorsed the Regents' plan, as an important step in helping move more schools into using the kind of technology that will be key to their future effectiveness.

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